FIG. 1

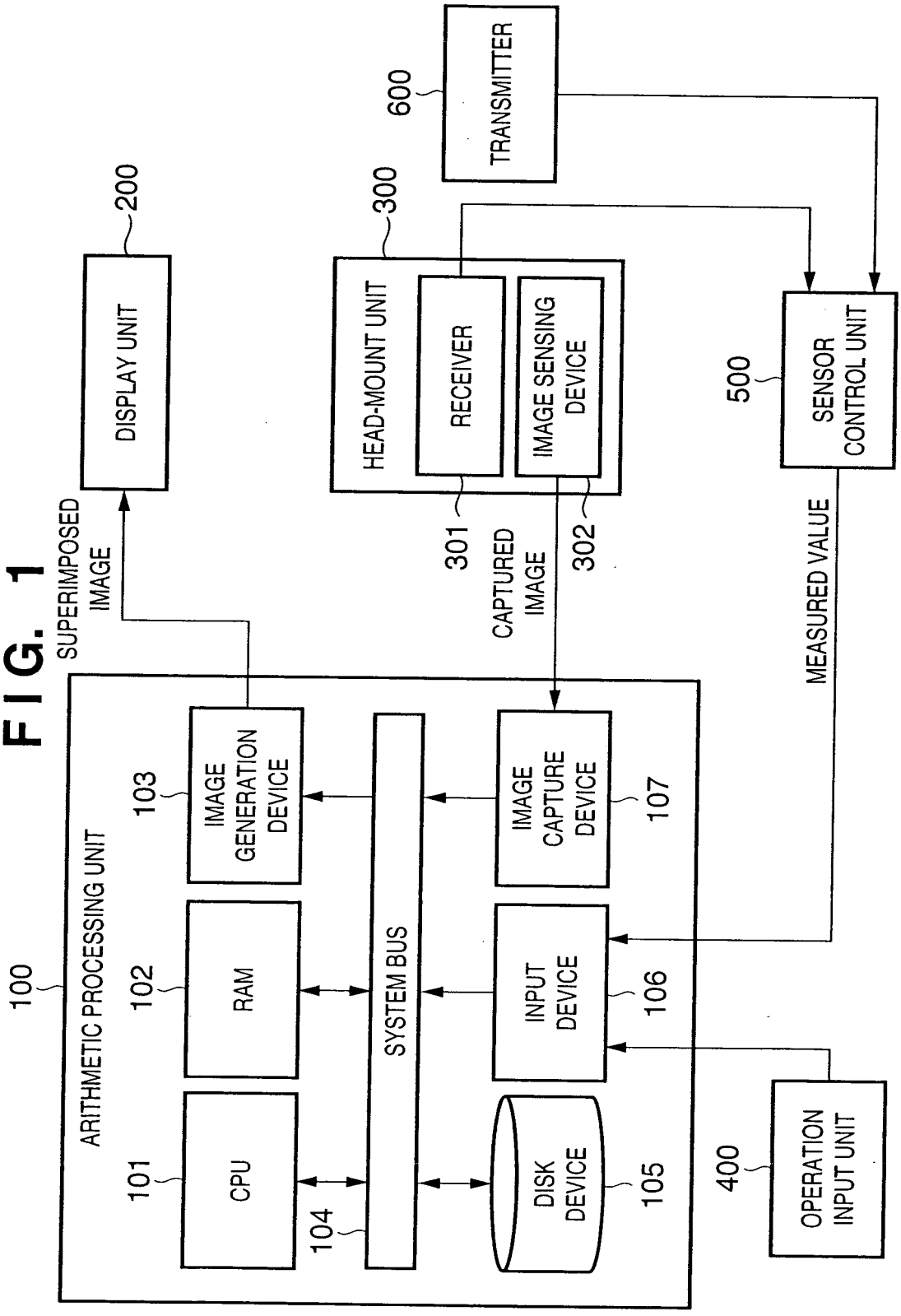

100
ARITHMETIC PROCESSING UNIT
101
CPU
102
RAM
103
IMAGE GENERATION DEVICE
104
SYSTEM BUS
105
DISK DEVICE
106
INPUT DEVICE
107
IMAGE CAPTURE DEVICE
200
DISPLAY UNIT
SUPERIMPOSED IMAGE
300
HEAD-MOUNT UNIT
301
RECEIVER
302
IMAGE SENSING DEVICE
CAPTURED IMAGE
400
OPERATION INPUT UNIT
500
SENSOR CONTROL UNIT
MEASURED VALUE
600
TRANSMITTER

FIG. 2

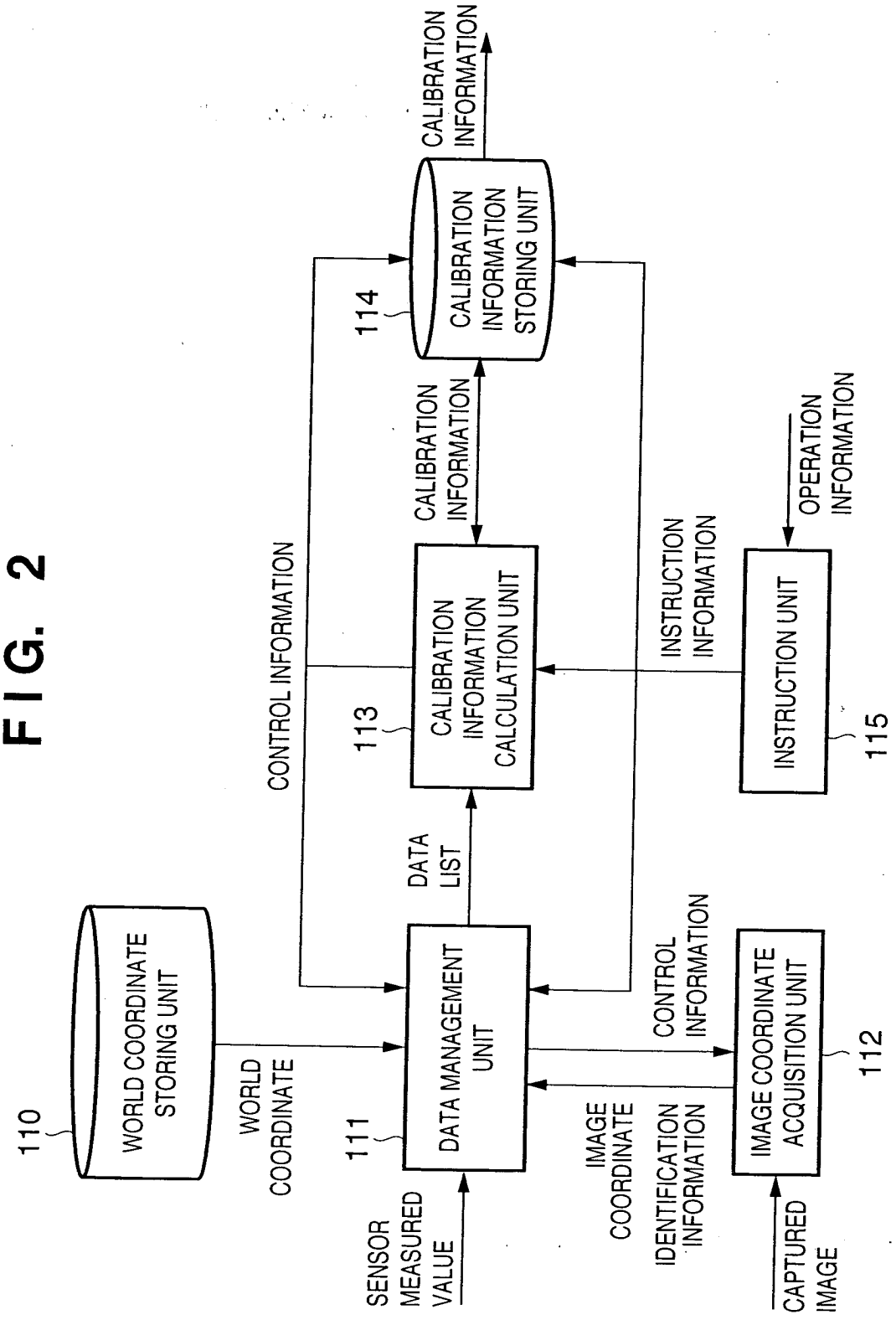

110
WORLD COORDINATE STORING UNIT
WORLD COORDINATE
111
DATA MANAGEMENT UNIT
SENSOR MEASURED VALUE
DATA LIST
CONTROL INFORMATION
113
CALIBRATION INFORMATION CALCULATION UNIT
CALIBRATION INFORMATION
114
CALIBRATION INFORMATION STORING UNIT
CALIBRATION INFORMATION
CONTROL INFORMATION
IMAGE COORDINATE
IDENTIFICATION INFORMATION
112
IMAGE COORDINATE ACQUISITION UNIT
CAPTURED IMAGE
INSTRUCTION INFORMATION
115
INSTRUCTION UNIT
OPERATION INFORMATION

FIG. 3

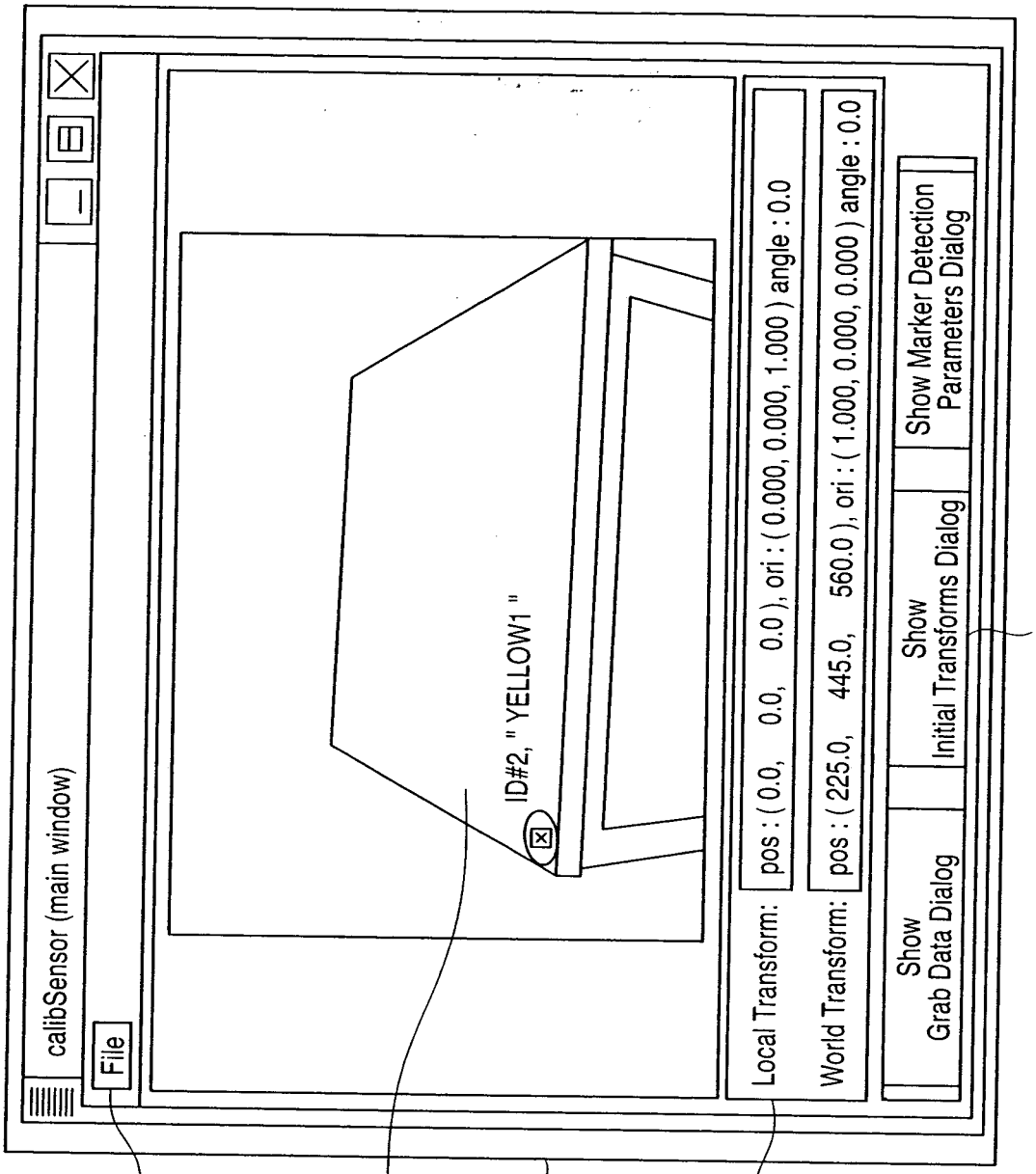

calibSensor (main window)
File
ID#2, " YELLOW1 "
Local Transform:
pos : (0.0, 0.0, 0.0), ori : (0.000, 0.000, 1.000) angle : 0.0
World Transform:
pos : (225.0, 445.0, 560.0), ori : (1.000, 0.000, 0.000) angle : 0.0
Show Grab Data Dialog
Show Initial Transforms Dialog
Show Marker Detection Parameters Dialog
1040
1010
1000
1020
1030

FIG. 4

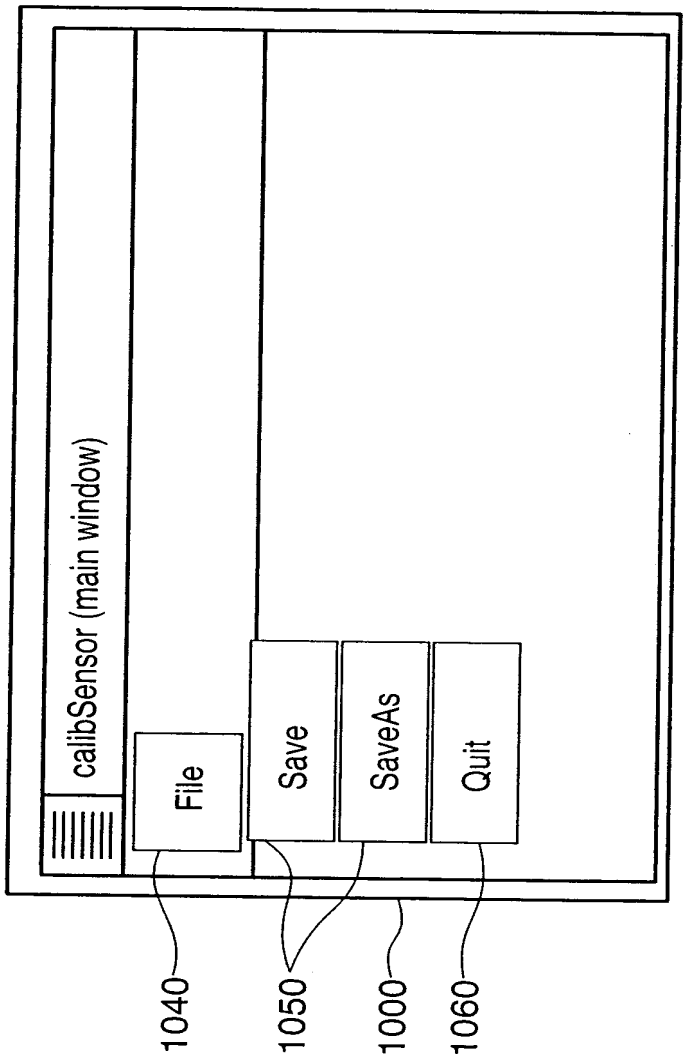

calibSensor (main window)
File
Save
SaveAs
Quit
1040
1050
1000
1060

FIG. 5

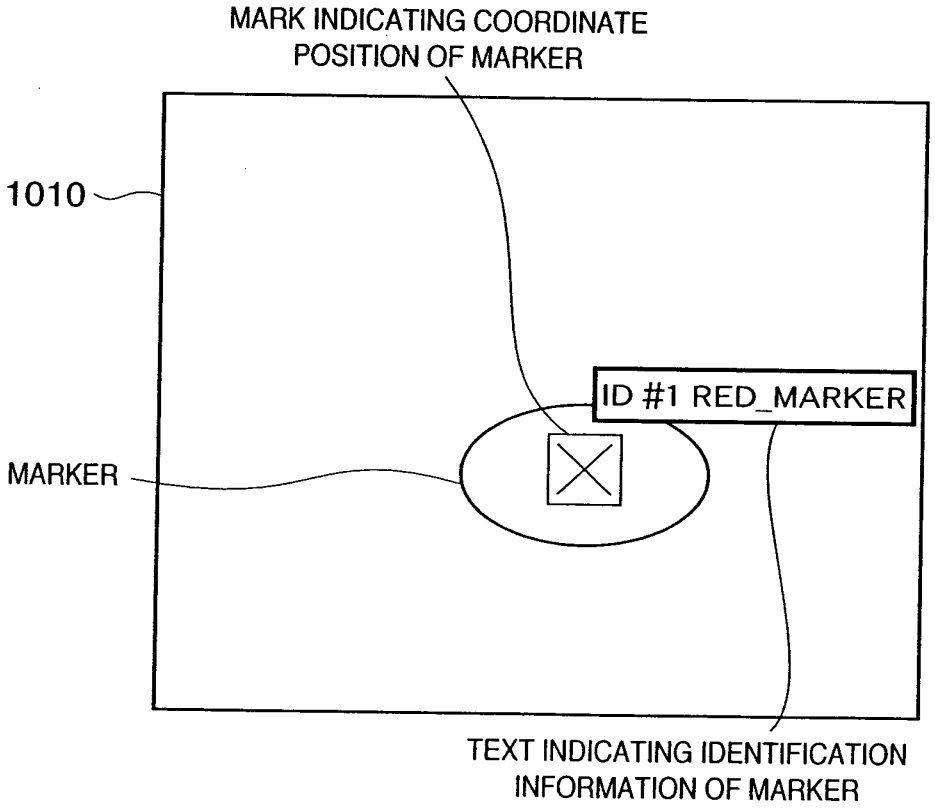

MARK INDICATING COORDINATE POSITION OF MARKER
1010
ID #1 RED_MARKER
MARKER
TEXT INDICATING IDENTIFICATION INFORMATION OF MARKER

FIG. 6

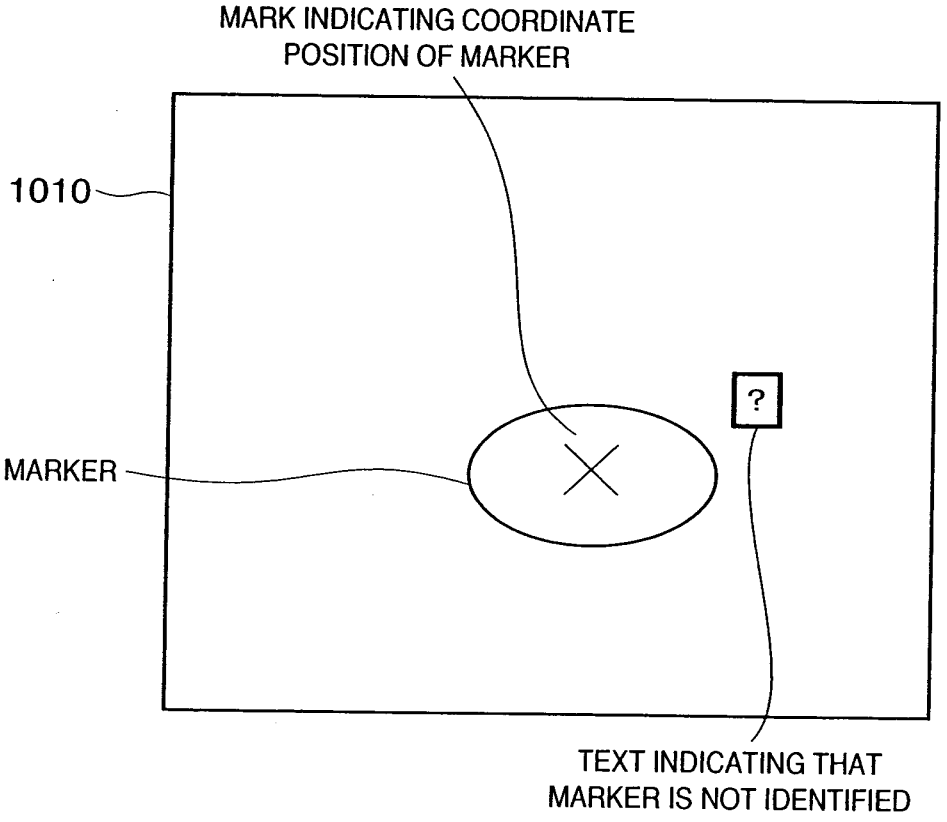

MARK INDICATING COORDINATE POSITION OF MARKER
1010
MARKER
?
TEXT INDICATING THAT MARKER IS NOT IDENTIFIED

FIG. 7

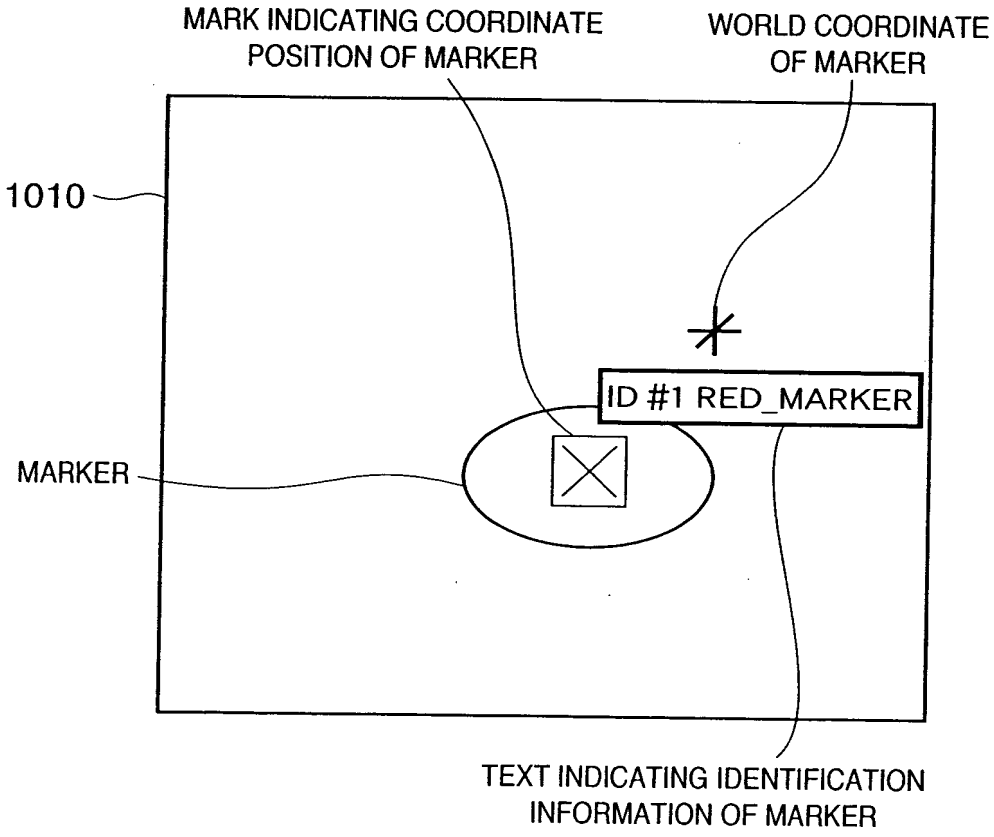

MARK INDICATING COORDINATE POSITION OF MARKER
WORLD COORDINATE OF MARKER
1010
ID #1 RED_MARKER
MARKER
TEXT INDICATING IDENTIFICATION INFORMATION OF MARKER

FIG. 8

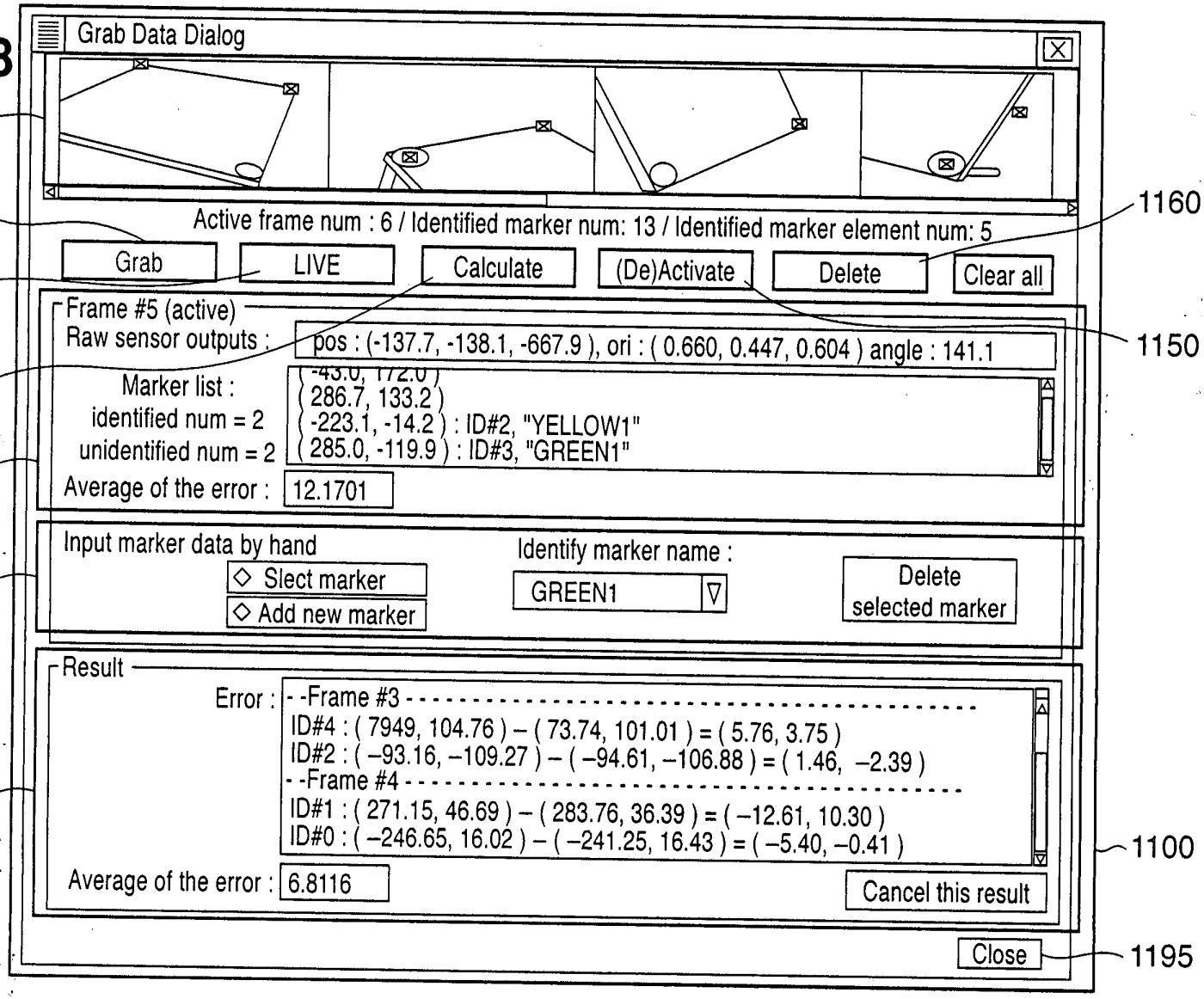

Grab Data Dialog
1110
1120
Active frame num : 6 / Identified marker num: 13 / Identified marker element num: 5
1160
Grab
LIVE
Calculate
(De)Activate
Delete
Clear all
1130
Frame #5 (active)
Raw sensor outputs :
pos : (-137.7, -138.1, -667.9), ori : (0.660, 0.447, 0.604) angle : 141.1
1140
1150
Marker list :
identified num = 2
unidentified num = 2
(286.7, 133.2)
(-223.1, -14.2) : ID#2, "YELLOW1"
(285.0, -119.9) : ID#3, "GREEN1"
1170
Average of the error :
12.1701
Input marker data by hand
Identify marker name :
1180
◇ Slect marker
◇ Add new marker
GREEN1
Delete selected marker
Result
Error :
- -Frame #3 -
ID#4 : (7949, 104.76) – (73.74, 101.01) = (5.76, 3.75)
ID#2 : (–93.16, –109.27) – (–94.61, –106.88) = (1.46, –2.39)
- -Frame #4 -
ID#1 : (271.15, 46.69) – (283.76, 36.39) = (–12.61, 10.30)
ID#0 : (–246.65, 16.02) – (–241.25, 16.43) = (–5.40, –0.41)
1190
1100
Average of the error :
6.8116
Cancel this result
Close
1195

FIG. 9

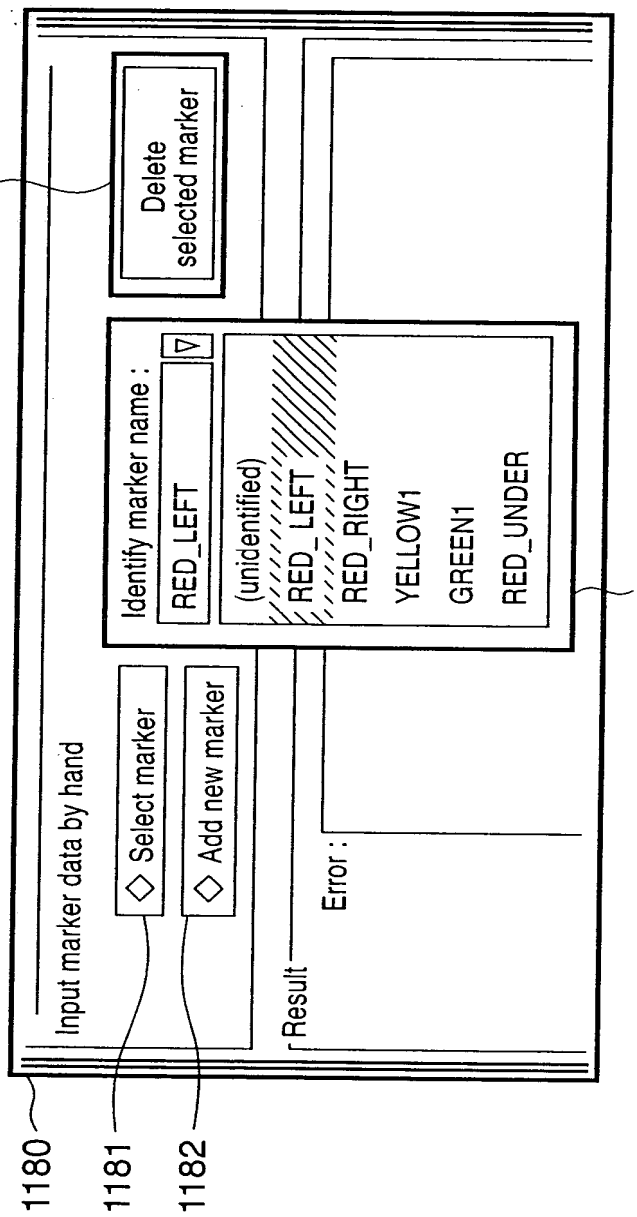

Input marker data by hand
Select marker
Add new marker
Identify marker name :
RED_LEFT
(unidentified)
RED_LEFT
RED_RIGHT
YELLOW1
GREEN1
RED_UNDER
Delete selected marker
Result
Error :
1180
1181
1182
1183
1184

FIG. 10

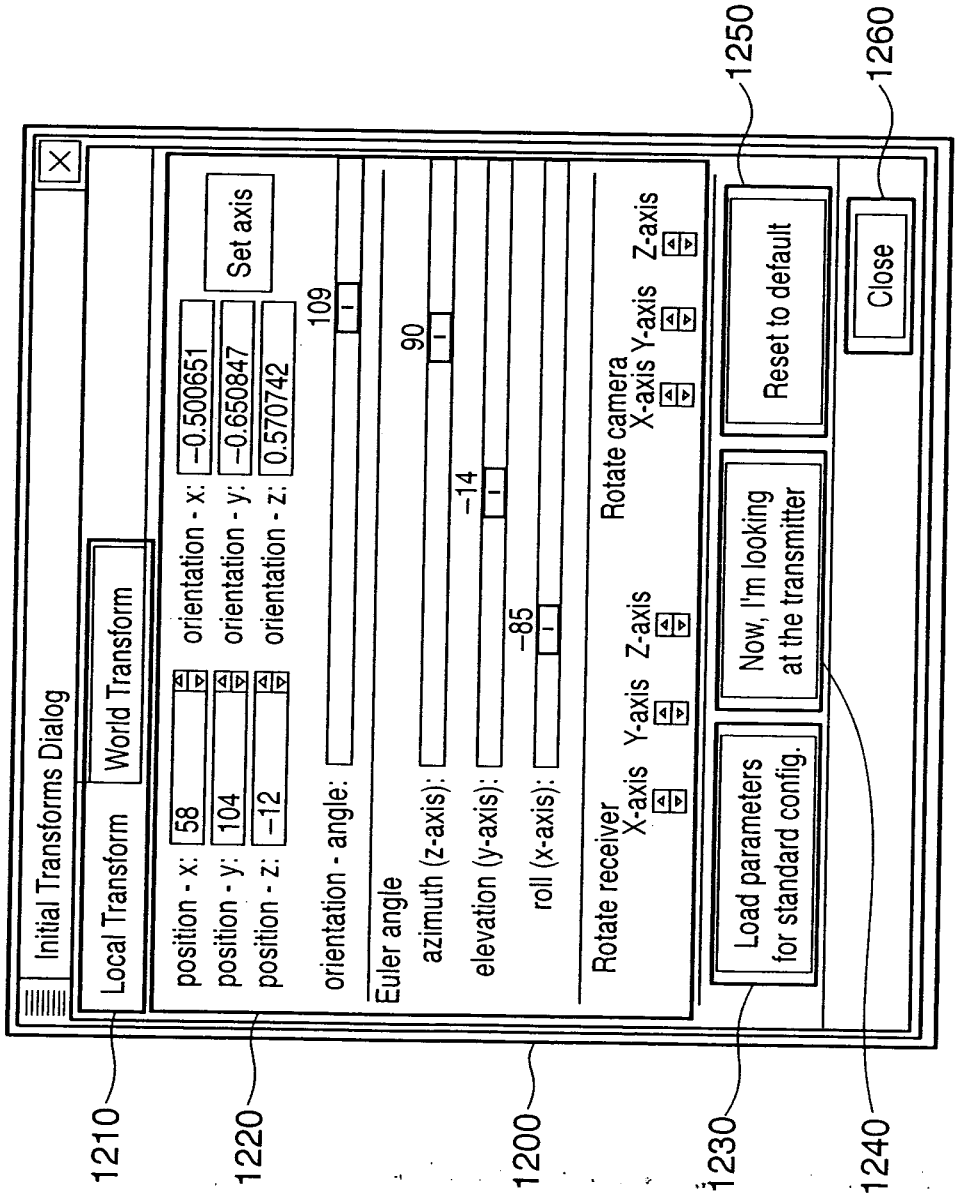

Initial Transforms Dialog
Local Transform
World Transform
position - x: 58
position - y: 104
position - z: −12
orientation - x: −0.500651
orientation - y: −0.650847
orientation - z: 0.570742
Set axis
orientation - angle: 109
Euler angle
azimuth (z-axis): 90
elevation (y-axis): −14
roll (x-axis): −85
Rotate receiver
X-axis Y-axis Z-axis
Rotate camera
X-axis Y-axis Z-axis
Load parameters for standard config.
Now, I'm looking at the transmitter
Reset to default
Close
1210
1220
1200
1230
1240
1250
1260

FIG. 11

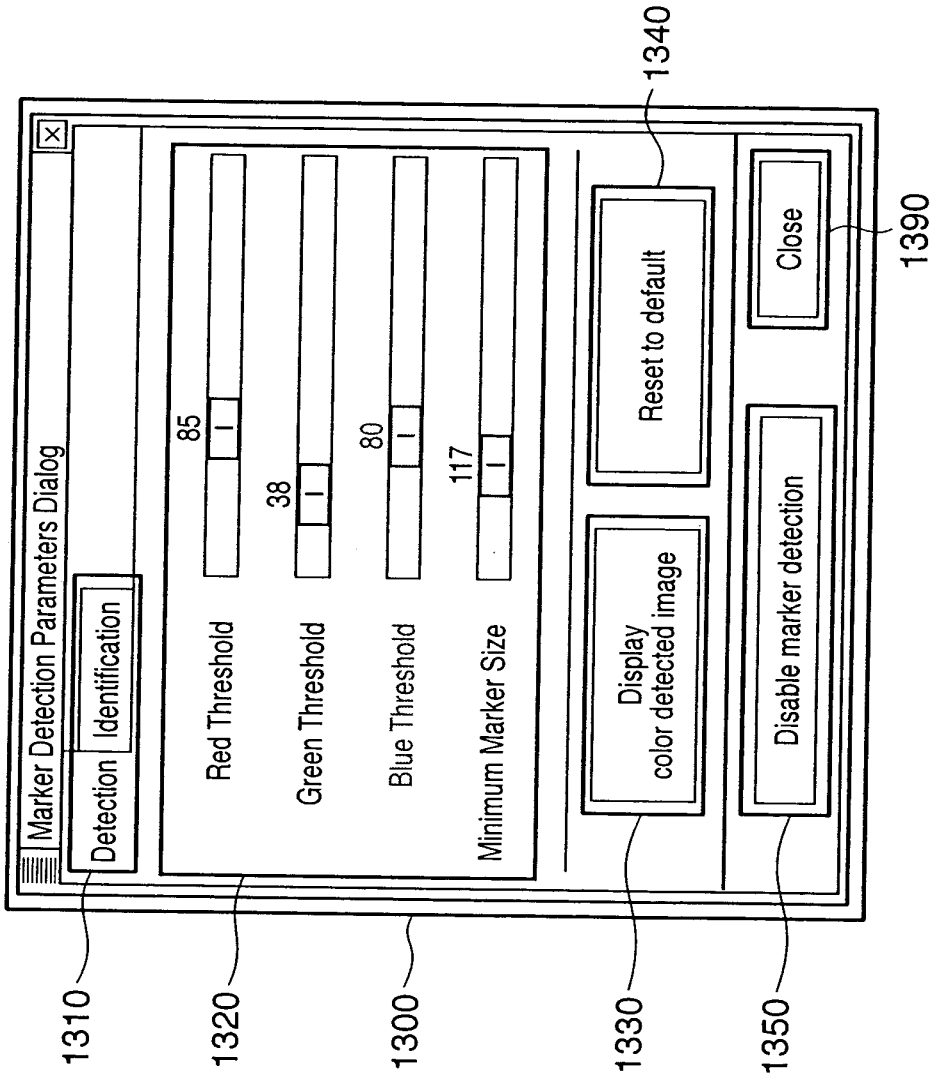

Marker Detection Parameters Dialog
Detection
Identification
Red Threshold
85
Green Threshold
38
Blue Threshold
80
Minimum Marker Size
117
Reset to default
Display color detected image
Disable marker detection
Close
1310
1320
1300
1330
1350
1340
1390

FIG. 12

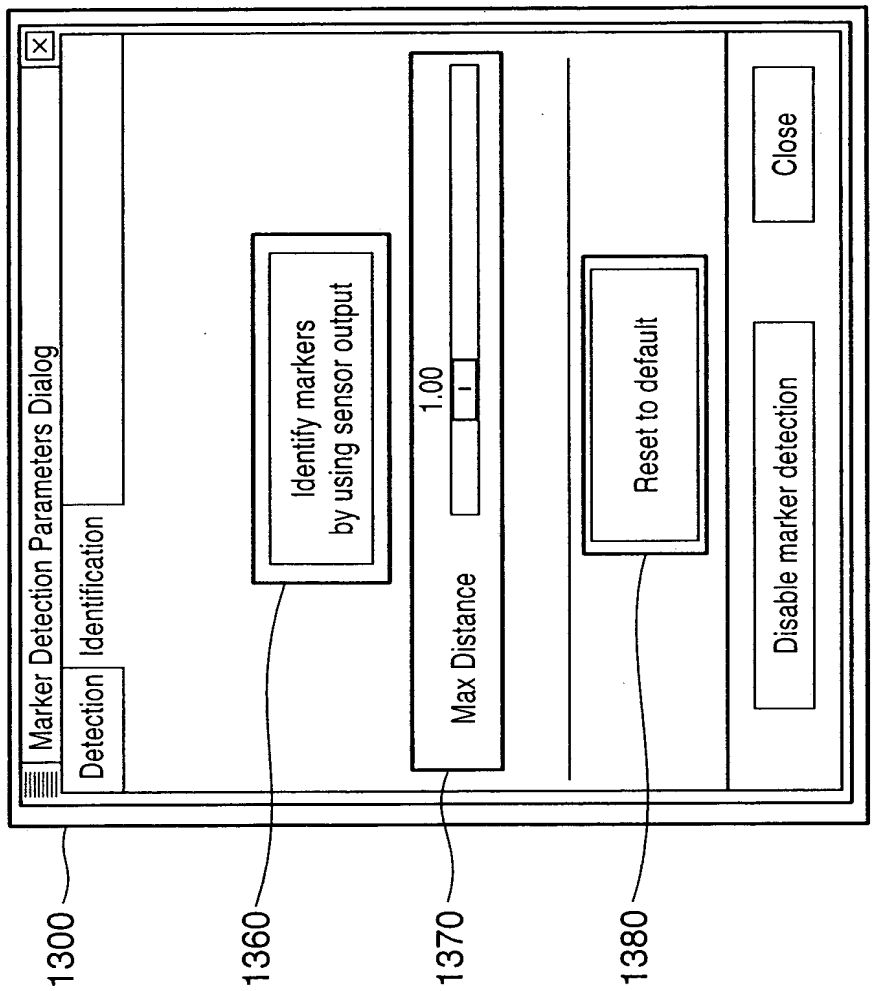

Marker Detection Parameters Dialog
Detection
Identification
Identify markers by using sensor output
1.00
Max Distance
Reset to default
Disable marker detection
Close
1300
1360
1370
1380

FIG. 13

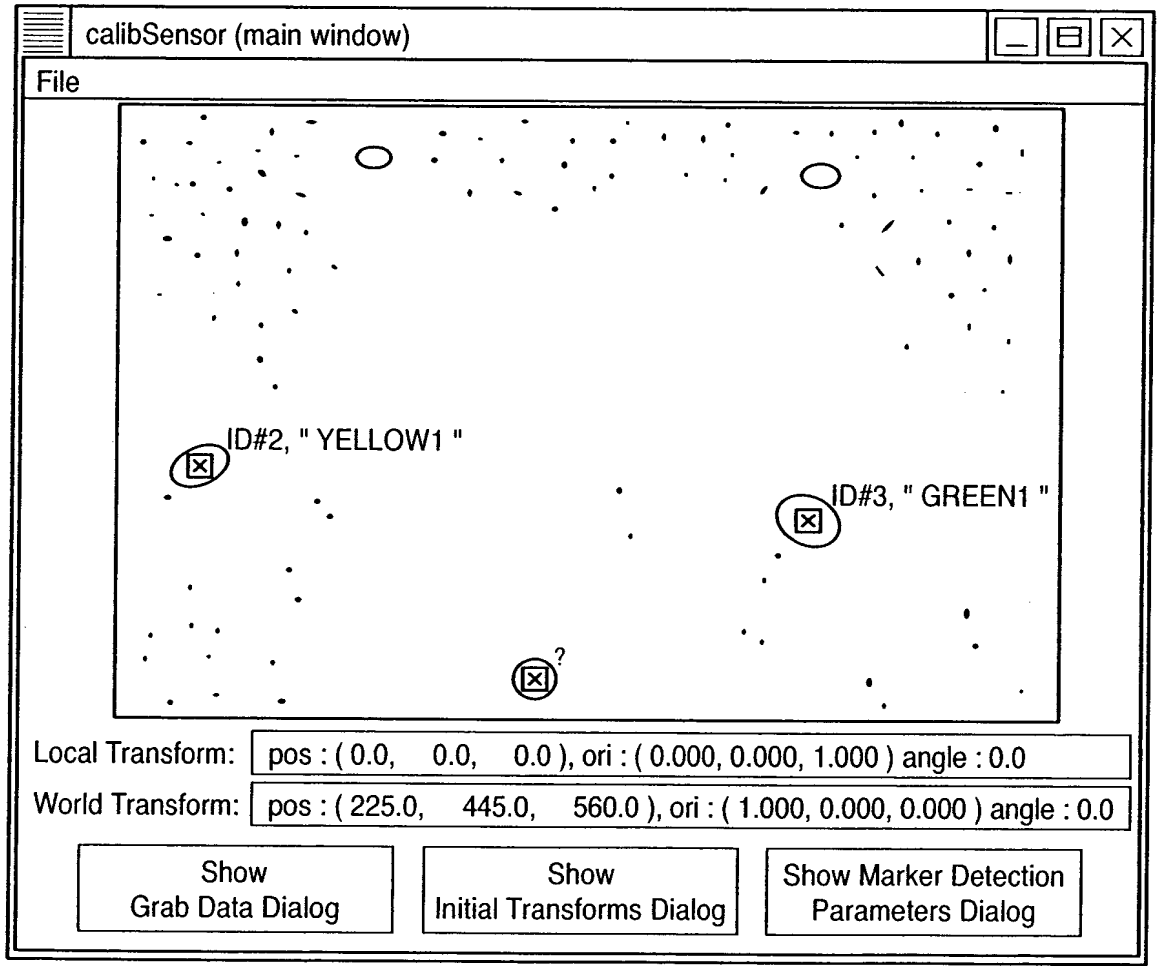

calibSensor (main window)
File
ID#2, " YELLOW1 "
ID#3, " GREEN1 "
?
Local Transform:
pos : (0.0, 0.0, 0.0), ori : (0.000, 0.000, 1.000) angle : 0.0
World Transform:
pos : (225.0, 445.0, 560.0), ori : (1.000, 0.000, 0.000) angle : 0.0
Show Grab Data Dialog
Show Initial Transforms Dialog
Show Marker Detection Parameters Dialog

FIG. 14A

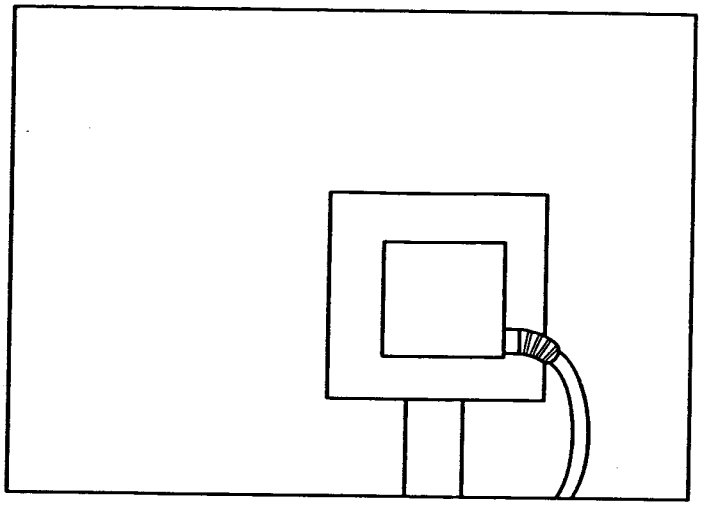


FIG. 14B

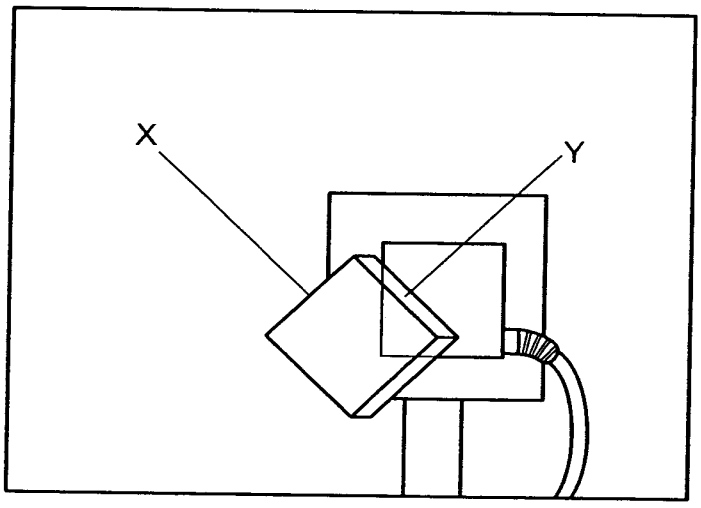


FIG. 14C

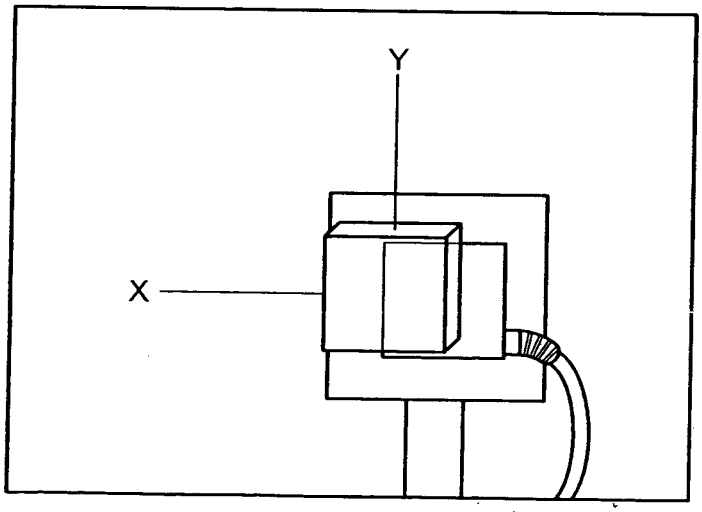


FIG. 15

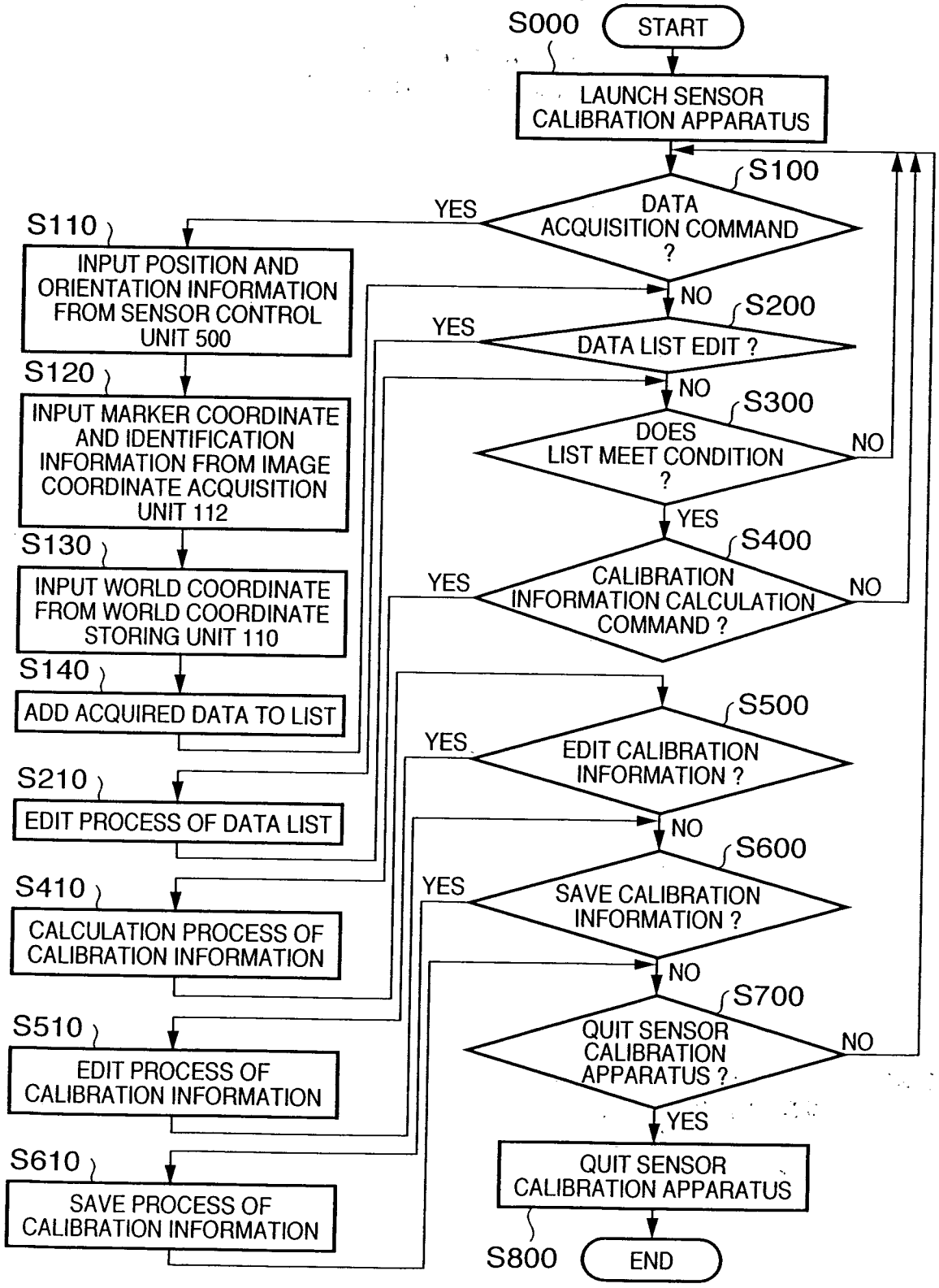

S000
START
LAUNCH SENSOR CALIBRATION APPARATUS
S100
DATA ACQUISITION COMMAND ?
YES
NO
S110
INPUT POSITION AND ORIENTATION INFORMATION FROM SENSOR CONTROL UNIT 500
S120
INPUT MARKER COORDINATE AND IDENTIFICATION INFORMATION FROM IMAGE COORDINATE ACQUISITION UNIT 112
S130
INPUT WORLD COORDINATE FROM WORLD COORDINATE STORING UNIT 110
S140
ADD ACQUIRED DATA TO LIST
S200
DATA LIST EDIT ?
YES
NO
S210
EDIT PROCESS OF DATA LIST
S300
DOES LIST MEET CONDITION ?
YES
NO
S400
CALIBRATION INFORMATION CALCULATION COMMAND ?
YES
NO
S410
CALCULATION PROCESS OF CALIBRATION INFORMATION
S500
EDIT CALIBRATION INFORMATION ?
YES
NO
S510
EDIT PROCESS OF CALIBRATION INFORMATION
S600
SAVE CALIBRATION INFORMATION ?
YES
NO
S610
SAVE PROCESS OF CALIBRATION INFORMATION
S700
QUIT SENSOR CALIBRATION APPARATUS ?
YES
NO
QUIT SENSOR CALIBRATION APPARATUS
S800
END

FIG. 16

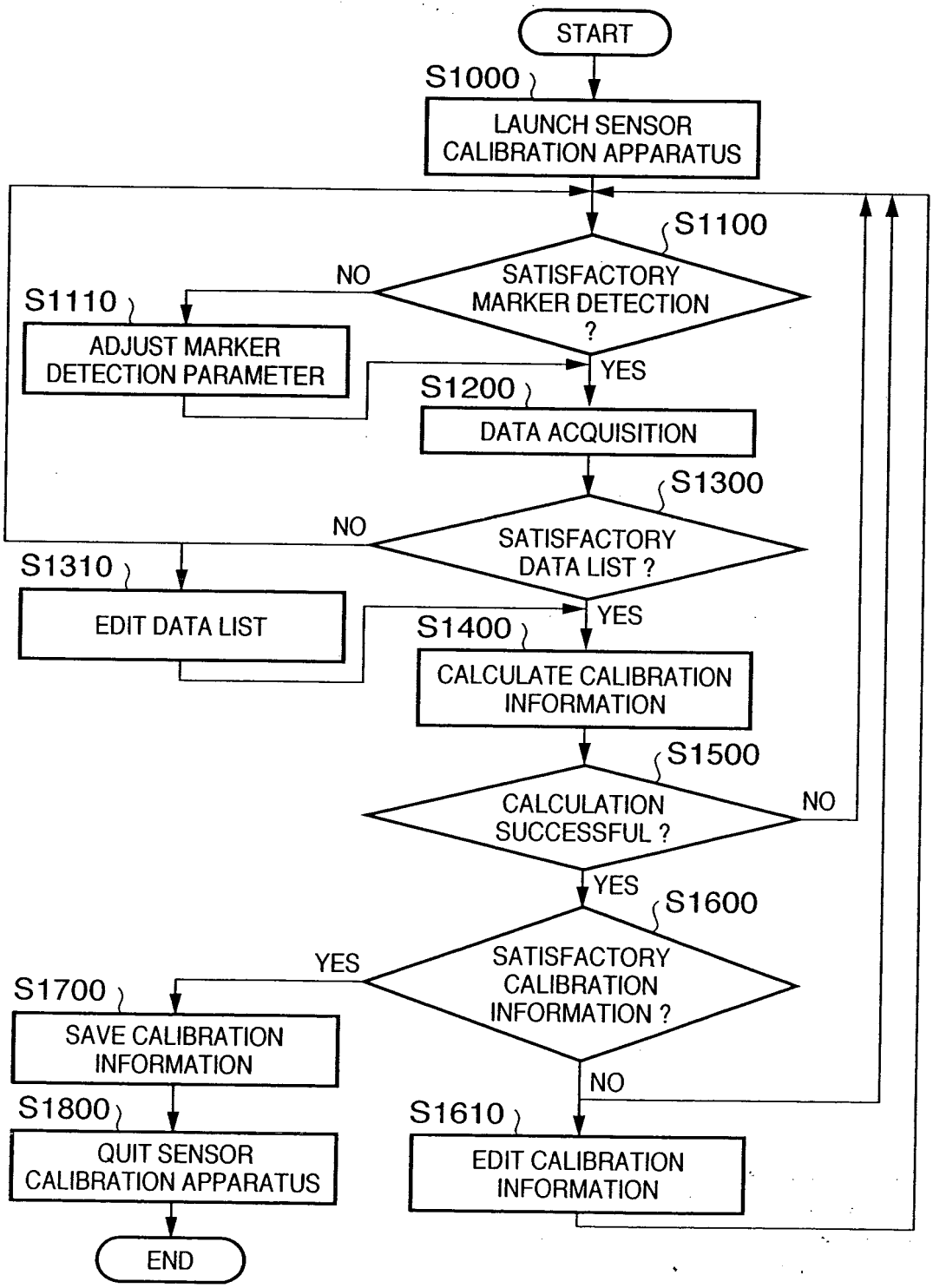

START
S1000
LAUNCH SENSOR CALIBRATION APPARATUS
S1100
SATISFACTORY MARKER DETECTION ?
NO
S1110
ADJUST MARKER DETECTION PARAMETER
YES
S1200
DATA ACQUISITION
S1300
SATISFACTORY DATA LIST ?
NO
S1310
EDIT DATA LIST
YES
S1400
CALCULATE CALIBRATION INFORMATION
S1500
CALCULATION SUCCESSFUL ?
NO
YES
S1600
SATISFACTORY CALIBRATION INFORMATION ?
YES
S1700
SAVE CALIBRATION INFORMATION
S1800
QUIT SENSOR CALIBRATION APPARATUS
END
NO
S1610
EDIT CALIBRATION INFORMATION

FIG. 17

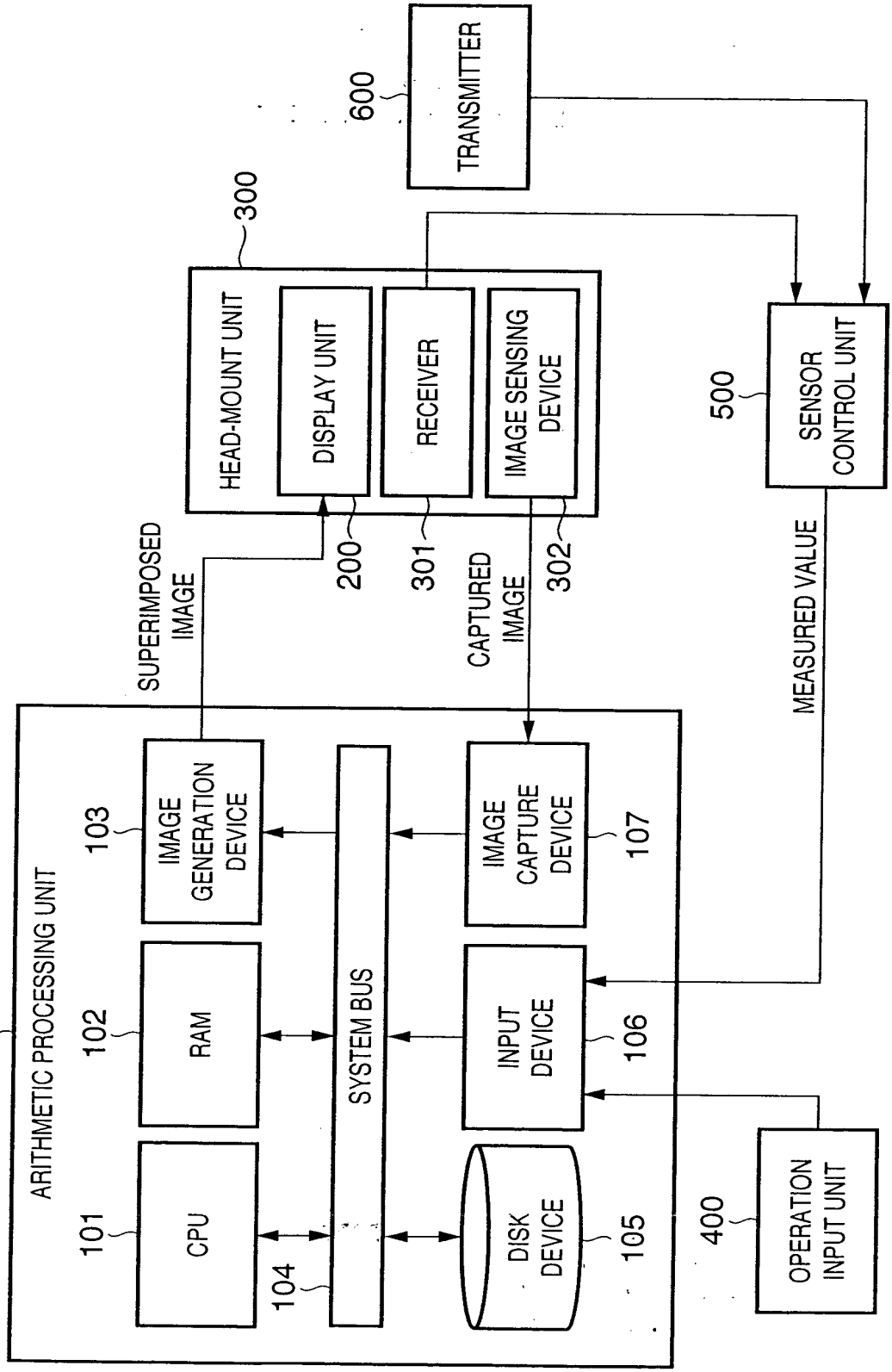

TRANSMITTER
600
HEAD-MOUNT UNIT
300
DISPLAY UNIT
RECEIVER
IMAGE SENSING DEVICE
SENSOR CONTROL UNIT
500
200
301
302
SUPERIMPOSED IMAGE
CAPTURED IMAGE
MEASURED VALUE
ARITHMETIC PROCESSING UNIT
100
IMAGE GENERATION DEVICE
103
IMAGE CAPTURE DEVICE
107
RAM
102
SYSTEM BUS
INPUT DEVICE
106
CPU
101
DISK DEVICE
105
104
OPERATION INPUT UNIT
400

FIG. 18

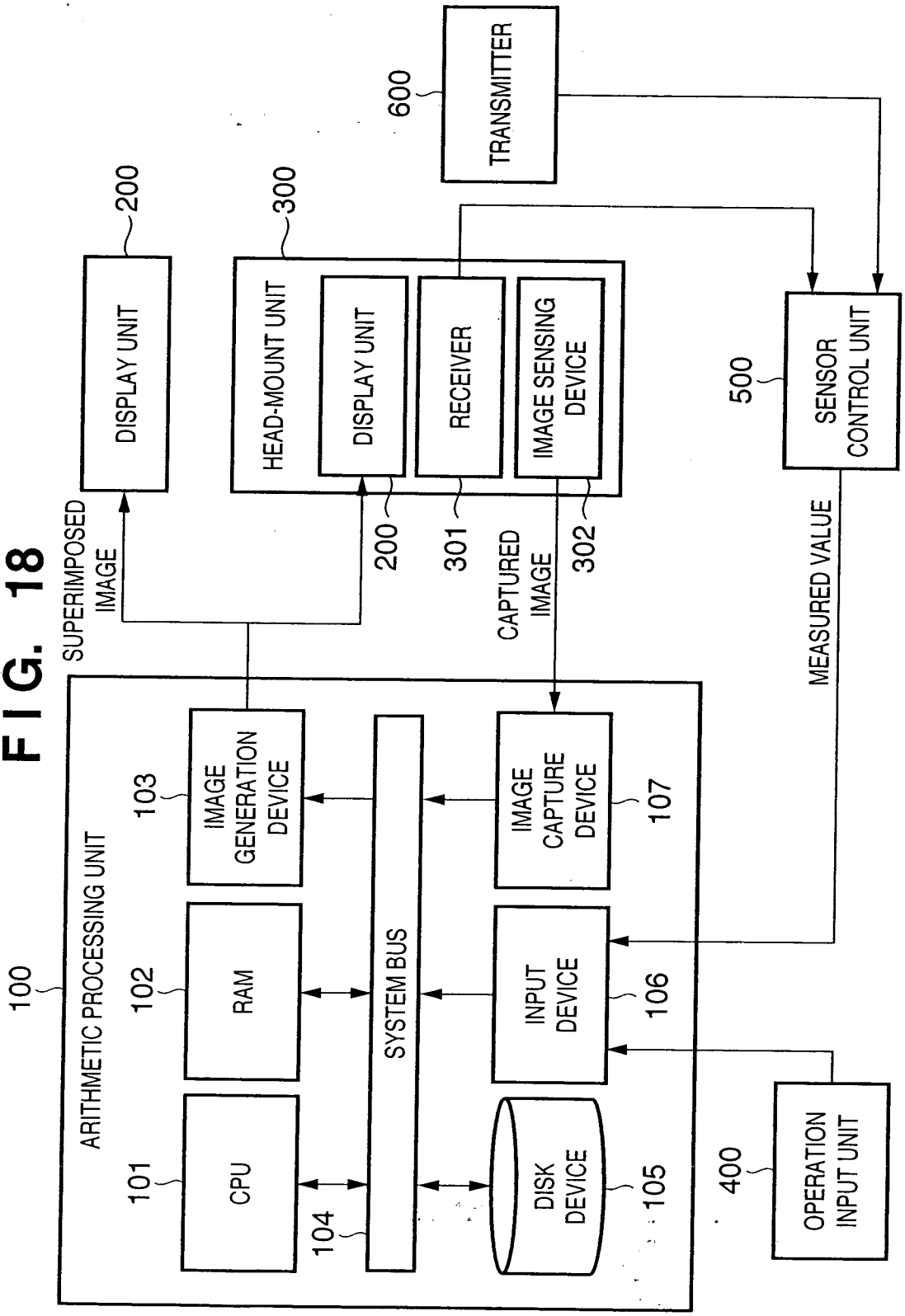
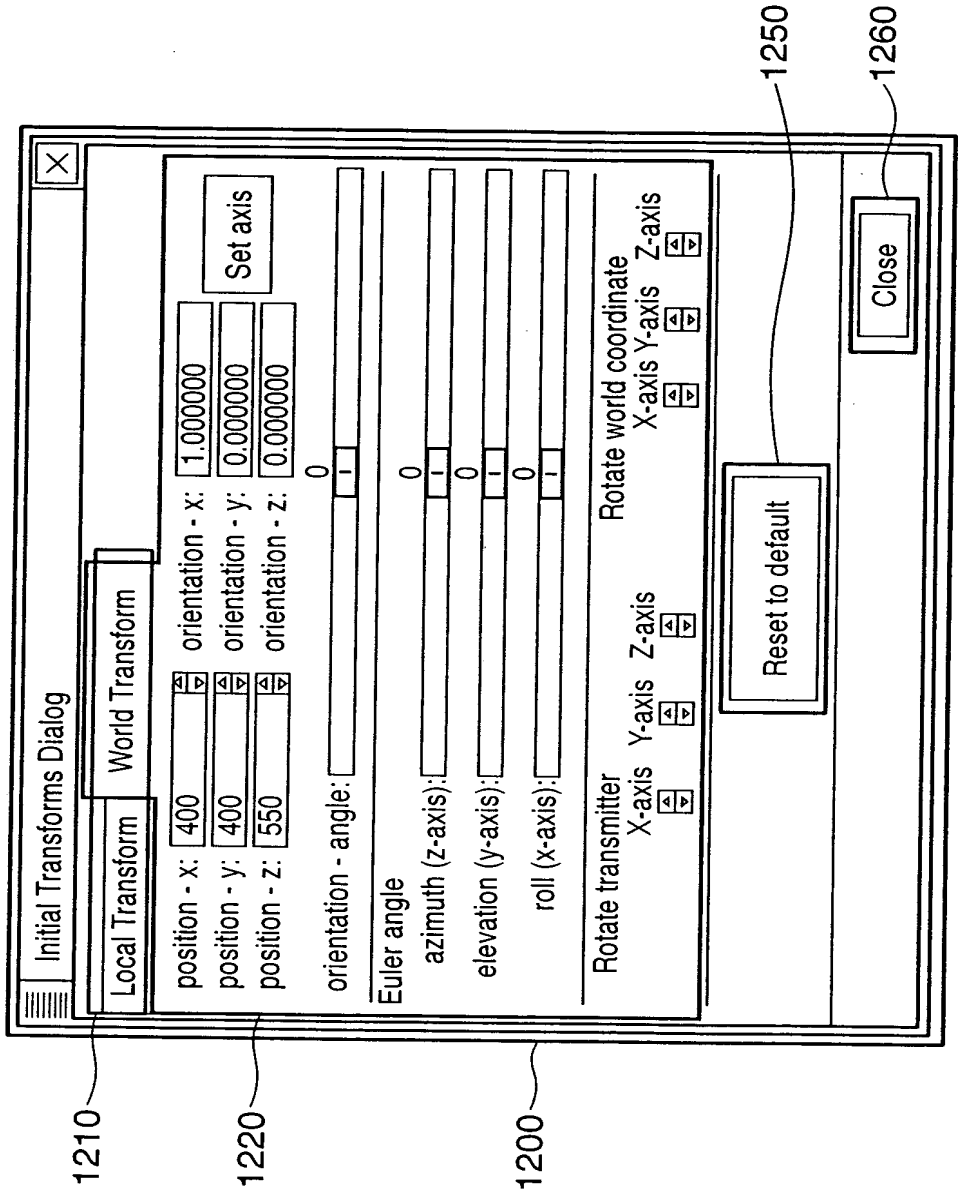

100
ARITHMETIC PROCESSING UNIT
101
CPU
102
RAM
103
IMAGE GENERATION DEVICE
104
SYSTEM BUS
105
DISK DEVICE
106
INPUT DEVICE
107
IMAGE CAPTURE DEVICE
200
DISPLAY UNIT
300
HEAD-MOUNT UNIT
DISPLAY UNIT
RECEIVER
IMAGE SENSING DEVICE
301
302
SUPERIMPOSED IMAGE
CAPTURED IMAGE
600
TRANSMITTER
500
SENSOR CONTROL UNIT
MEASURED VALUE
400
OPERATION INPUT UNIT

FIG. 19


Initial Transforms Dialog
Local Transform
World Transform
position - x: 400
position - y: 400
position - z: 550
orientation - x: 1.000000
orientation - y: 0.000000
orientation - z: 0.000000
Set axis
orientation - angle: 0
Euler angle
azimuth (z-axis): 0
elevation (y-axis): 0
roll (x-axis): 0
Rotate transmitter
X-axis Y-axis Z-axis
Rotate world coordinate
X-axis Y-axis Z-axis
Reset to default
Close
1210
1220
1200
1250
1260